

**HYDROLOGY STUDY FOR
BLACK WARRIOR MINERALS, INC.**

**SEABOARD MINE
P-3937 Revision R-5
TUSCALOOSA COUNTY, ALABAMA**

**BY
PERC ENGINEERING CO., INC.
P.O. BOX 1712
JASPER, ALABAMA 35502**

**DETAILED DESIGN PLANS
BASIN 021 RE-EVALUATION
ATTACHMENT III-B-2(a)**

OCTOBER 15, 2014



Telephone: (205) 384-5553
Facsimile: (205) 295-3114 - Main Building
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Web Address: www.percengineering.com

October 15, 2014

Mr. Michael Harrison, P.E.
Alabama Surface Mining Commission
Post Office Box 2390
Jasper, Alabama 35502-2390

RE:Black Warrior Minerals, Inc.
Seaboard Mine
P- 3937 Revision R-5

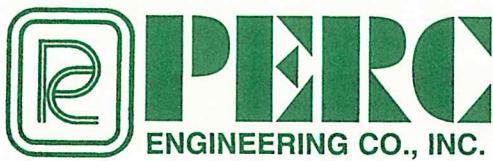
Dear Michael:

Please find attached a copy of the Detailed Design Plans for Basin 021 Re-evaluation for the above referenced permit. Please process as necessary.

If you have any questions or required additional information, please feel free to call.

Sincerely,
PERC Engineering Co., Inc.

Leslie G. Stephens
P.L.S./P.E.



Telephone: (205) 384-5553
Facsimile: (205) 295-3114 - Main Building
(205) 295-3115 - Water Lab
Web Address: www.percengineering.com

October 15, 2014

Mr. Michael Harrison, P.E.
Alabama Surface Mining Commission
Post Office Box 2390
Jasper, Alabama 35502-2390

RE:Black Warrior Minerals, Inc.

Seaboard Mine
P- 3937 Revision R-5

Dear Michael:

I hereby certify the attached Detailed Design Plans for Basin 021 Re-evaluation for the above referenced mine are in accordance with the Regulations of the Alabama Surface Mining Commission as adopted by Act 81-435 of December 18, 1981 and amended to date, and are true and correct to the best of my knowledge, information and belief.

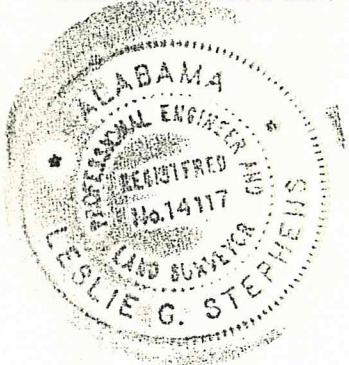
If you have any questions or required additional information, please feel free to call at 205-295-3127 or e-mail lstephens@percengineering.com

Sincerely,
PERC Engineering Co., Inc.

A handwritten signature in black ink that reads "Leslie G. Stephens".

Leslie G. Stephens, P.E. & P.L.S.

AL. REG. NO. 14117-E



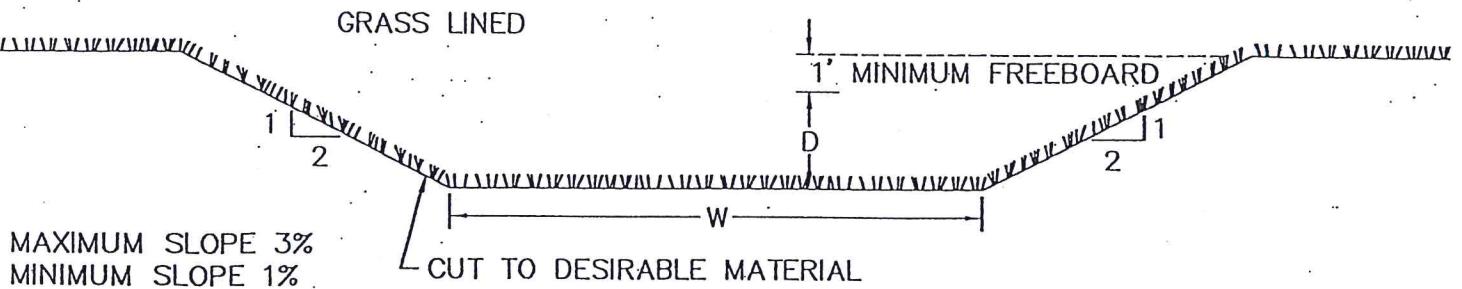
Pond Construction Criteria

The embankment for sediment basins (temporary and permanent) shall be designed and built using the following as minimum criteria:

1. The top of the dam shall be no less than 12 feet wide.
2. See design sheet for maximum and minimum embankment slopes.
3. The foundation and abutments for the impounding structure shall be designed to be stable under all conditions of construction and operation of the impoundments, with a minimum static safety factor of 1.3 for the normal pool with steady seepage saturation conditions.
4. The dam shall be constructed with a cutoff trench based upon prudent engineering practices for the site. The cutoff shall be located on the dam centerline and be of sufficient depth to extend into a relatively impervious material from which the core of the dam shall also be constructed.
5. The embankment foundation area shall be cleared of all organic matter, all surfaces sloped to no steeper than lv:lh, and the entire foundation surface scarified.
6. The entire embankment and cutoff trench shall be compacted to 95 percent density, based on standard proctor as outlined in ASTM.
7. The material placed in the embankment shall be free of sod, roots, stones over 6 inches in diameter, and other objectionable materials. The fill material shall be placed and spread over the entire fill area, starting at the lowest point of the foundation, in layers not to exceed 12 inches in thickness. Construction of the fill shall be undertaken only at such times that the moisture content of the fill material will permit satisfactory compaction in accordance with paragraph 5.
8. The pool area of all basins will be cleared of timber and large undergrowth.
9. The primary decant system when consisting of a pipe shall be installed according to Class C pipe installation for embankment bedding.
10. The primary decant system shall be equipped with a device, or constructed, such as to insure that subsurface withdrawal is accomplished to prevent discharge of floating solids. If a channel is used as the primary decant a skimmer shall be installed to prevent floating solids from discharging.
11. A splash pad or riprap may be required under the discharge of the primary decant system where necessary to insure that the discharge does not erode the embankment.

12. The combination primary and secondary decant system shall be designed to safely carry the expected peak flow from a 25 year - 6 hour storm. The entire emergency overflow spillway channel will be a stabilized channel and will be stabilized upon completion of construction as specified within the detailed design plans using prudent engineering measures. These measures may consist of lining the spillway with concrete or a durable rock riprap, or the spillway being constructed in consolidated non-erodible material and planted with a mixture or both annual and perennial grasses, or a combination of any or all of the above.
13. Sediment basins using a single spillway system shall be an open channel of non-erodible construction consisting of concrete, durable rock riprap or its being constructed in consolidated non-erodible material as specified in the detailed design plans.
14. The settled embankment for temporary impoundments shall be a minimum of 1.0 foot above the maximum water elevation for the runoff from a 25 year - 6 hour, or a 10 year - 24 hour precipitation event (whichever has the greatest runoff). The settled embankment for permanent impoundments shall be a minimum of 1.0 foot above the maximum water elevation for the runoff from a 25 year - 6 hour, or a 10 year - 24 hour precipitation event or greater event as specified by the Regulatory Authority. (whichever has the greatest runoff).
15. If basins are built in series, then the combined decant system for each shall be designed to accommodate the entire contributing drainage area.
16. The dam and all disturbed areas shall be seeded with both perennial and annual grasses, fertilized and mulched in order to insure erosion is minimized. Hay bales or riprap may be placed at the toe of the dam immediately upon completion of construction.
17. The constructed height of the dam shall be increased a minimum of 5 percent over the design height to allow for settlement over the life of the embankment.
18. Final graded slopes of the entire permanent water impoundment area shall not exceed 2.5H-1.0V to provide for adequate safety and access for proposed water users.
19. Prior to Phase II bond release, additional data concerning water quality, water quantity, depth, size, configuration, postmining land use, etc., for each proposed permanent water impoundment, shall be submitted to the Regulatory Authority for permanent water impoundment approval.
20. All sediment basins will be inspected for stability, erosion, etc. two (2) times a month until removal of the structure or release of the reclamation bond.

21. The embankment and spillway will be maintained by repairing any damage such as erosion, slope failure or spillway damage until removal of the structure or release of the performance bond.
22. All ponds shall be examined quarterly for structural weakness, instability, erosion, or other hazardous conditions and maintenance performed as necessary. Formal inspections shall be made on an annual basis, including any reports or modifications, in accordance with 880-X-10C-.20[1(j)] of the Alabama Surface Mining Commission Regulations.
23. Sediment will be removed from each pond when the accumulated sediment reaches the sediment storage volume as shown on the detailed design sheet.
24. Upon completion of mining, successful reclamation and effluent standards being met, each sediment basin not remaining as a permanent water impoundment will be dewatered in an environmentally safe manner (such as siphoning, pumping, etc.) and reclaimed to approximate original contours by the following procedure: A permanent diversion channel (designed for a 10 year - 24 hour precipitation event) shall be cut along the outer edge of the basin to re-route drainage around the basin and back through the stabilized spillway to allow reclamation of the sediment basin. The diversion channel shall be designed and grassed as per enclosed information. (See permanent diversion for basin disposal). Upon completion of the diversion channel the back slope of the dam shall be graded to a minimum 3H to 1V slope. The dewatered sediment basin area shall be seeded with some combination of the following: Fescue, Bermuda, rye grass, canary grass and willows. After seeding the area shall be mulched. Any additional sediment or embankment material not used to meet original contour, if non-toxic, shall be spread in thin layers within the permit area and vegetated as stated in the approved reclamation plan. All toxic material encountered in the basin disposal shall be buried and covered with 4 feet of non-toxic material and vegetated as stated in the approved reclamation plan.
25. A qualified registered professional engineer or other qualified professional specialist, under the direction of the professional engineer shall conduct regular inspections during construction and upon completion shall inspect each basin for certification purposes.
26. Point source discharge embankments shall be constructed and abutments keyed into desirable material if at all possible. In the event that undesirable material is encountered, addition design and construction criteria shall be submitted prior to certification.



$$Q = \frac{1.49}{N} A R^{2/3} S^{1/2}$$

N (loose stone or grass lined) = 0.035

A = area

R = area/wetted perimeter

S = slope

* Grass lining: fescue, bermuda, rye grass

DIVERSION CHANNEL DEPTH (D) FOR WDTN (W) 8.0 Ft.	
PEAK FLOW Q (CFS)	DEPTH D (Ft.)
0-15	0.5
15-50	1.0
50-100	1.5
100-180	2.0
180-270	2.5

DIVERSION CHANNEL DEPTH (D) FOR WDTN (W) 10.0 Ft.	
PEAK FLOW Q (CFS)	DEPTH D (Ft.)
0-15	0.5
15-60	1.0
60-120	1.5
120-210	2.0
210-320	2.5

DIVERSION CHANNEL DEPTH (D) FOR WDTN (W) 12.0 Ft.	
PEAK FLOW Q (CFS)	DEPTH D (Ft.)
0-20	0.5
20-70	1.0
70-150	1.5
150-250	2.0
250-383	2.5

DIVERSION CHANNEL DEPTH (D) FOR WDTN (W) 15.0 Ft.	
PEAK FLOW Q (CFS)	DEPTH D (Ft.)
0-25	0.5
25-90	1.0
90-180	1.5
180-300	2.0
300-450	2.5

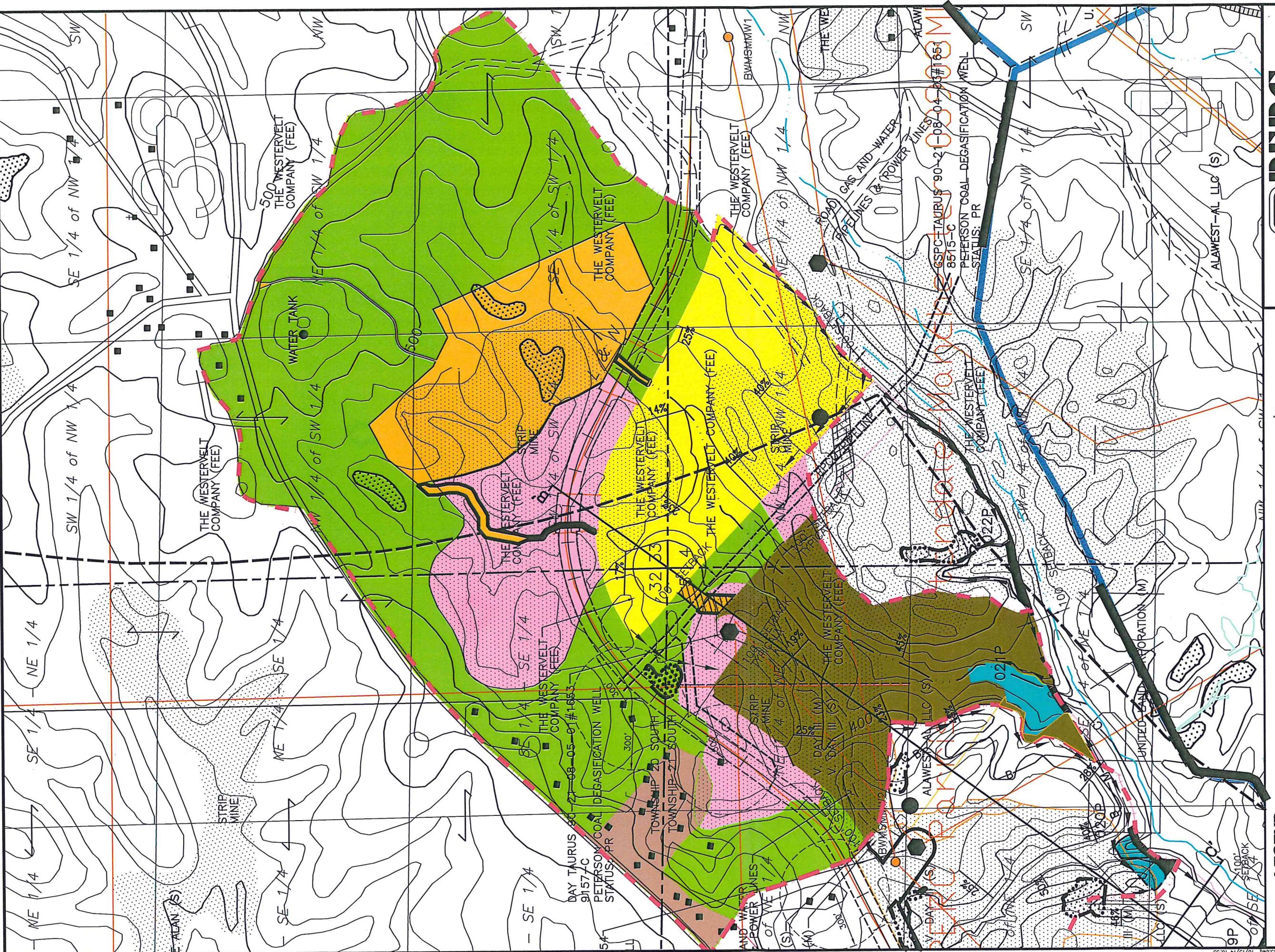


PERMANENT DIVERSION CHANNEL FOR BASIN DISPOSAL

DRAWN BY:	DATE:
APPROVED BY:	SCALE: NONE

NOTES

- 1) The primary spillway of Basin 021 Re-evaluation, consisting of a 10 foot wide open channel lined with 4 inches of concrete reinforced with 6x6 – W2.9 x W2.9 wire. The channel lining will extend back to the existing drainage course. The spillway also will consist of a 3 inch diameter PVC Siphon Tube constructed to the lines and grades as detailed within the design plans. A 12' X 16' X 4" concrete splash pad is located at the end of the Siphon Tube which discharges onto the existing drainage course.
- 2) The normal pool will be constructed down to the Carter Coal Seam as shown by the Plan View within these Detailed Design Plans for Basin 021 Re-evaluation.
- 3) Any coal seams, within the construction area, for Basin 021 Re-evaluation will be removed and stockpiled during the Basin construction.
- 4) No Modification is required from the previously approved plans.
- 5) A silt fence will be placed below the downstream toe location of the embankment during construction.



PIERC ENGINEERING CO., INC.
1000 Highway 70 • Tuscaloosa, AL 35401 • (205) 352-2114
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Email: pierc@pierc.com

BLACK WARRIOR MINERALS, INC.
SEABOARD MINE
ATTACHMENT III - B - 2 (a)

P-3937 R-5 / WATERSHED MAP

DRAWN BY: S.W.L.	DATE: 10-15-2014
DWG. NAME: BWSB2WS	
APPROVED BY: L.G.S.	SCALE: 1"=500'

LAND USE, ACREAGE AND CURVE NUMBER INFORMATION

Category	Value
37.72 Ac.	RE-VEGETATED 2-12 MONTHS, CURVE NUMBER 74
33.80 Ac.	RE-VEGETATED 12-24 MONTHS, CURVE NUMBER 74
129.25 Ac.	UNMANAGED TIMBERLAND, CURVE NUMBER, 70
28.0 Ac.	GRADED & BARE, CURVE NUMBER, 81
26.72 Ac.	SEDIMENT BASIN, CURVE NUMBER, 100
8.1 Ac.	PREVIOUSLY DISTURBED, CURVE NUMBER 68
	URBAN AREA, CURVE NUMBER, 80

LEGEND

- PERMIT BOUNDARY (Red dashed line)
- DRAINAGE DIVIDE (Black line)
- DIVERSION (Blue line)

Scale: 1" - 100'



NORMAL POOL LEVEL
ELEV. 342.25

3" DIA. FIXED SIPHON TUBE
CREST ELEV. 344.25
INLET ELEV. 342.25

12"x16"x4" CONCRETE
SPLASH PAD AT TOE OF DAM

TOP OF SKIMMERBOARD
ELEV. 348.1

CONCRETE
SPILLWAY INVERT
ELEV. 344.75

LEGEND

- Existing Contour
- Proposed Contour
- Major Inflow
- Normal Pool Level
Elev. 344.75
- F-1 Foundation Material
- D-1 Dam Material
- Concrete Spillway



BLACK WARRIOR MINERALS, INC.
SEABOARD MINE
P-3937 R-5
BASIN 021P RE-EVALUATION PLANVIEW

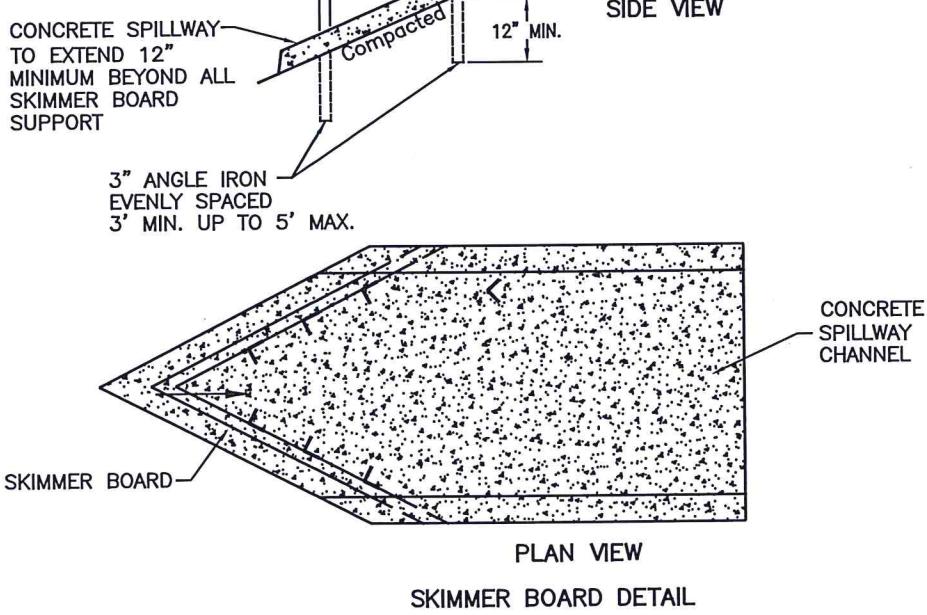
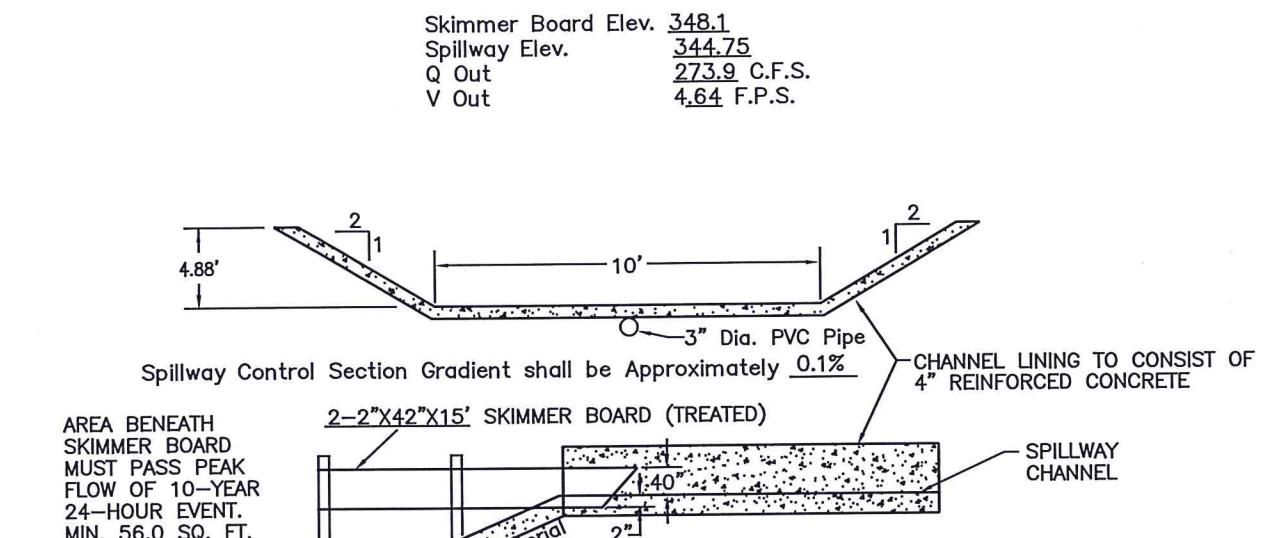
DRAWN BY: S.A.E.	DATE: 10-15-2014
DWG. NAME: BWMSM21PV	
APPROVED BY: L.G.S.	SCALE: 1"=100'

Storage Computation

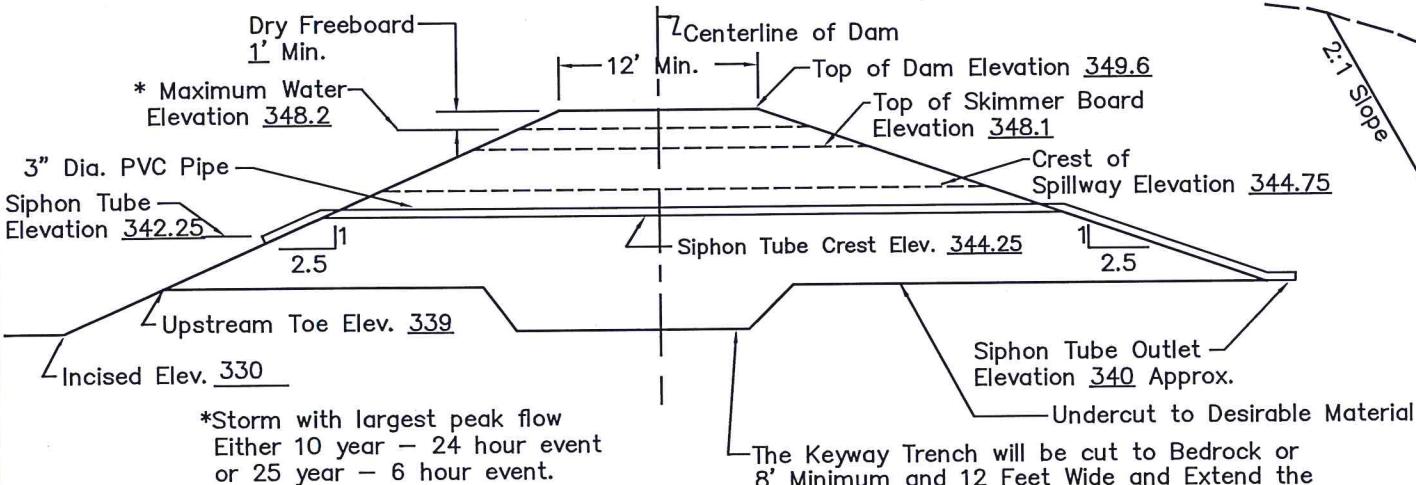
Elevation (feet)	Area (acres)	Avg. Area (acres)	Interval (feet)	Storage (ac.-ft.)	Acc. Storage (ac.-ft.)
330	0.000	0.575	2	0.767	0.000
332	1.150	1.197	2	2.393	0.767
334	1.244	1.291	2	2.581	3.160
336	1.338	1.389	2	2.777	5.741
338	1.439	1.496	2	2.991	8.518
340	1.553	1.637	2	3.272	11.509
342	1.720	1.732	0.25	0.433	14.781
342.25	1.744	1.831	1.75	3.203	15.214
344	1.918	1.929	0.25	0.482	18.417
344.25	1.940	1.963	0.5	0.982	18.899
344.75	1.986	2.044	1.25	2.554	19.881
346	2.101	2.233	2	4.463	22.435
348	2.365	2.436	1	2.435	26.898
349	2.506	2.558	1	2.561	29.333
350	2.610				31.891

Notes:

- The sediment shall be removed from the basin when the accumulated sediment reaches the sediment storage volume.
- Outer slopes of embankment shall be grassed.
- Fill material shall be placed in 12" lifts and compacted to 95% of standard proctor.
- The surface beneath the embankment shall be stripped of undesirable material.
- Upon completion of mining, reclamation and maintenance of water quality standards the pond will be de-watered and reclaimed.
- See the attached pond construction criteria.
- See the attached drawings and specifications for diversions.
- Elevations are based on assumed datum.
- Channel lining within the control section of the spillway channel will extend to the maximum water elevation.

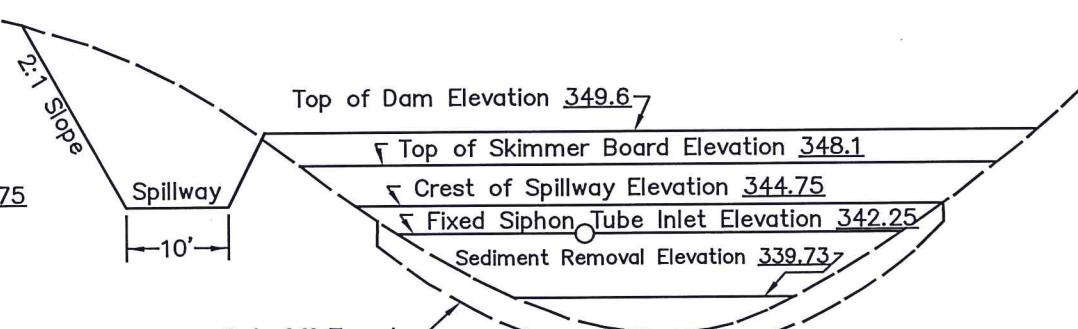
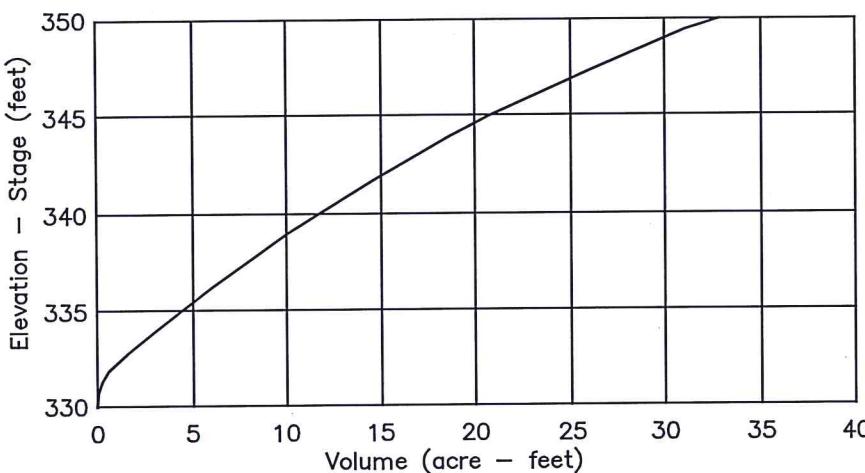


Spillway Tail Section Gradient shall be Approximately 40%



Typical Cross Section
Along Spillway

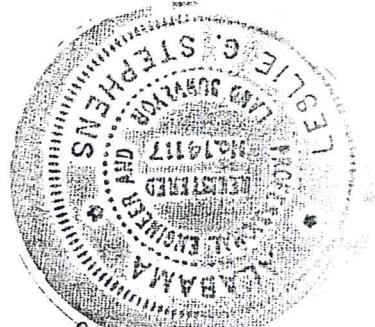
Stage vs. Storage Curve

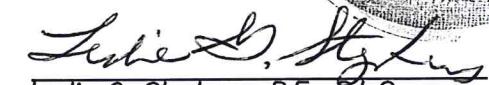


Typical Profile Looking Downstream

Drainage Area	265.6 Acres
Disturbed Area	101.5 Acres
Sediment Storage	11.1 Ac.-Ft.
Detention Storage	4.1 Ac.-Ft.
Pool Capacity @ Siphon Inlet	15.2 Ac.-Ft.
Pool Capacity @ Primary Spillway	19.9 Ac.-Ft.
Total Basin Capacity	27.4 Ac. Ft.
Peak Inflow	450.0 C.F.S.
Peak Outflow	273.9 C.F.S.

NOTE: 10.0 AC-FT INCISED UP TO 339.0 ELEVATION



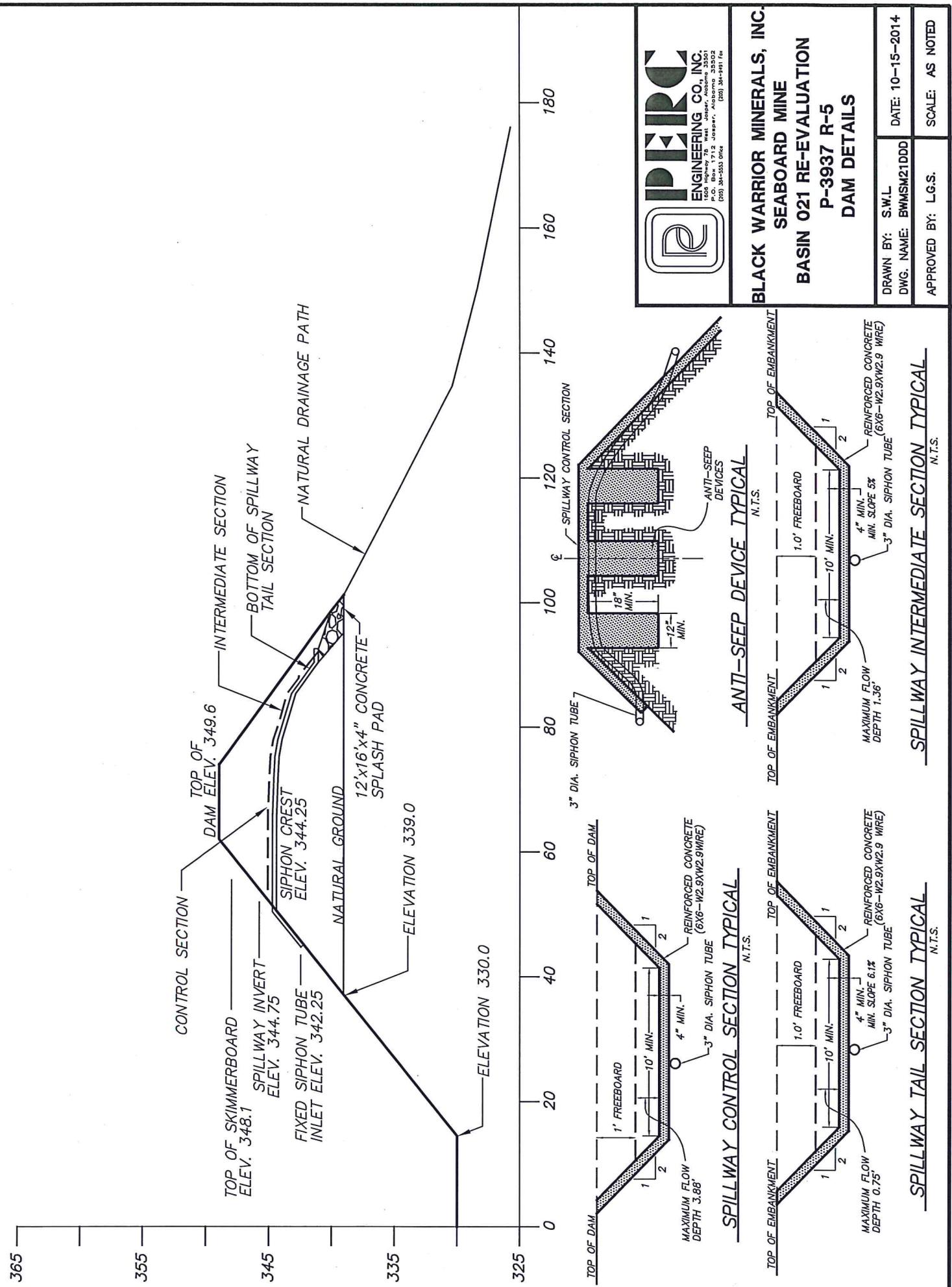
 10/15/2014
Leslie G. Stephens, P.E., P.L.S.
AL Registration. #14117-E
Date



BLACK WARRIOR MINERALS, INC.
SEABOARD MINE

P-3937 REVISION R-5
BASIN 021 RE-EVALUATION

DRAWN BY: S.A.E. DWG. NAME: BWMSM21DDT	DATE: 10-15-2014
APPROVED BY: L.G.S.	SCALE: NONE



Black Warrior Minerals, Inc. Seaboard Mine P-3937 R-5

Basin 021 Re-evaluation Spillway Control Section

Material: Concrete, Rubble

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
10.00	2.0:1	2.0:1	0.1	0.0220	1.00		

	w/o Freeboard	w/ Freeboard
Design Discharge:	273.90 cfs	
Depth:	3.88 ft	4.88 ft
Top Width:	25.54 ft	29.54 ft
Velocity:	3.97 fps	
X-Section Area:	69.03 sq ft	
Hydraulic Radius:	2.522 ft	
Froude Number:	0.43	

Black Warrior Minerals, Inc. Seaboard Mine P-3937 R-5 **Basin 021 Re-evaluation Spillway Intermediate Section**

Material: Concrete, Rubble

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
10.00	2.0:1	2.0:1	5.0	0.0220	1.00		

	w/o Freeboard	w/ Freeboard
Design Discharge:	273.90 cfs	
Depth:	1.36 ft	2.36 ft
Top Width:	15.43 ft	19.43 ft
Velocity:	15.88 fps	
X-Section Area:	17.25 sq ft	
Hydraulic Radius:	1.074 ft	
Froude Number:	2.65	

Black Warrior Minerals, Inc. Seaboard Mine P-3937 R-5

Basin 021 Re-evaluation Spillway Tail Section

Material: Concrete, Rubble

Trapezoidal Channel

Bottom Width (ft)	Left Sideslope Ratio	Right Sideslope Ratio	Slope (%)	Manning's n	Freeboard Depth (ft)	Freeboard % of Depth	Freeboard Mult. x (VxD)
10.00	2.0:1	2.0:1	40.0	0.0220	1.00		

	w/o Freeboard	w/ Freeboard
Design Discharge:	273.90 cfs	
Depth:	0.75 ft	1.75 ft
Top Width:	12.99 ft	16.99 ft
Velocity:	31.92 fps	
X-Section Area:	8.58 sq ft	
Hydraulic Radius:	0.643 ft	
Froude Number:	6.92	

Black Warrior Minerals, Inc.
Seaboard Mine
P-3937 R-5
Basin 021 Re-evaluation
Hydrology & Sedimentology
10 Yr. - 24 Hr. Event

BLACK WARRIOR MINERALS, INC.

SEABOARD MINE

P-3937 Revision R-5

BASIN 021 Re-evaluation

6.3 INCHES, 10 YEAR - 24 HOUR, DRN 58

LGS

PERC Engineering Co., Inc.
P.O. Box 1712
Jasper, Alabama 35502

Phone: 205-295-3127
Email: lstephens@percengineering.com

General Information***Storm Information:***

Storm Type:	DRN58
Design Storm:	10 yr - 24 hr
Rainfall Depth:	6.300 inches

Particle Size Distribution:

Size (mm)	TOPSOIL	SPOIL
3.0000	100.000%	100.000%
2.0000	90.000%	95.000%
1.0000	82.000%	85.000%
0.5000	73.000%	70.000%
0.3000	68.000%	50.000%
0.2000	63.000%	45.000%
0.1000	38.000%	20.000%
0.0500	20.000%	15.000%
0.0300	16.000%	13.000%
0.0200	14.000%	12.000%
0.0100	11.500%	7.500%
0.0050	10.000%	5.000%
0.0030	9.500%	4.000%
0.0010	8.500%	3.500%

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Pond	#1	==>	End	0.000	0.000	BASIN 021

#1
Pond

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Structure Summary:

		Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	In		265.590	270.34	66.93	5,229.7	112,393	82.03	40.88
	Out			251.99	62.78	281.1	7,860	0.01	0.00

Particle Size Distribution(s) at Each Structure***Structure #1:***

Size (mm)	In	Out
3.0000	100.000%	100.000%
2.0000	95.046%	100.000%
1.0000	85.089%	100.000%
0.5000	70.177%	100.000%
0.3000	50.427%	100.000%
0.2000	45.419%	100.000%
0.1000	20.376%	100.000%
0.0500	15.121%	100.000%
0.0300	13.079%	100.000%
0.0200	12.059%	100.000%
0.0100	7.589%	100.000%
0.0050	5.103%	94.962%
0.0030	4.111%	76.499%
0.0010	3.601%	67.003%

Structure Detail:

Structure #1 (Pond)

BASIN 021

Pond Inputs:

Initial Pool Elev:	342.25 ft
Initial Pool:	4.12 ac-ft
*Sediment Storage:	11.10 ac-ft
Dead Space:	20.00 %

**Sediment capacity was entered by user*

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
344.75	12.00	2.00:1	2.00:1	10.00

Fixed Siphon

Crest Elev	Inlet Elev	Outlet Elev	Diameter (in)	Length (ft)	Manning's n
344.25	342.25	340.00	3.00	100.00	0.0140

Pond Results:

Peak Elevation:	348.09 ft
H'graph Detention Time:	1.27 hrs
Pond Model:	CSTRS
Dewater Time:	9.48 days
Trap Efficiency:	94.63 %

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
339.73	1.538	0.000	0.000	Top of Sed. Storage
340.00	1.553	0.411	0.000	
340.50	1.594	1.198	0.000	
341.00	1.635	2.005	0.000	
341.50	1.677	2.833	0.000	
342.00	1.720	3.683	0.000	

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Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
342.25	1.744	4.116	0.000	
342.50	1.769	4.555	0.219	24.31*
343.00	1.818	5.451	0.242	44.87*
343.50	1.868	6.373	0.263	42.33*
344.00	1.918	7.319	0.284	40.39*
344.25	1.940	7.801	0.293	19.90* Spillway #2
344.50	1.963	8.289	0.303	19.51*
344.75	1.986	8.783	0.312	19.45 Spillway #1
345.00	2.009	9.282	5.198	3.50
345.50	2.055	10.298	14.970	1.35
346.00	2.101	11.337	39.684	7.25
346.50	2.166	12.403	74.992	3.25
347.00	2.231	13.502	119.604	0.70
347.50	2.298	14.634	174.153	0.35
348.00	2.365	15.800	238.944	0.25
348.09	2.378	16.008	251.988	0.05 Peak Stage
348.50	2.435	17.000	314.326	
349.00	2.506	18.235	400.666	
349.50	2.558	19.501	498.335	
350.00	2.610	20.793	607.703	

*Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Fixed Siphon (cfs)	Combined Total Discharge (cfs)
339.73	0.000	0.000	0.000
340.00	0.000	0.000	0.000
340.50	0.000	0.000	0.000
341.00	0.000	0.000	0.000
341.50	0.000	0.000	0.000
342.00	0.000	0.000	0.000
342.25	0.000	0.000	0.000
342.50	0.000	0.219*	0.219
343.00	0.000	0.242*	0.242
343.50	0.000	0.263*	0.263
344.00	0.000	0.284*	0.284
344.25	0.000	0.293	0.293
344.50	0.000	0.303	0.303

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Elevation (ft)	Emergency Spillway (cfs)	Fixed Siphon (cfs)	Combined Total Discharge (cfs)
344.75	0.000	0.312	0.312
345.00	4.877	0.321	5.198
345.50	14.631	0.338	14.970
346.00	39.329	0.355	39.684
346.50	74.621	0.371	74.992
347.00	119.218	0.386	119.604
347.50	173.752	0.401	174.153
348.00	238.528	0.416	238.944
348.50	313.896	0.430	314.326
349.00	400.222	0.444	400.666
349.50	497.877	0.458	498.335
350.00	607.233	0.471	607.703

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Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	28.000	0.036	0.158	0.364	81.000	F	38.68	9.689
	2	26.720	0.107	0.055	0.394	68.000	M	27.61	6.342
	3	129.250	0.132	0.065	0.389	70.000	M	109.37	26.653
	4	8.100	0.018	0.065	0.408	80.000	M	11.00	2.732
	5	2.000	0.000	0.000	0.000	100.000	F	3.30	1.049
	6	37.720	0.122	0.098	0.357	74.000	M	45.35	10.792
	7	33.800	0.014	0.000	0.000	74.000	M	40.64	9.671
Σ		265.590						270.34	66.927

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.240	200.00	35.00	0.9000	0.9000	2	4,812.9	511,398	373.59	226.65
	2	0.240	200.00	20.00	0.0500	1.0000	2	106.7	21,779	15.91	8.99
	3	0.300	200.00	15.00	0.0030	1.0000	1	30.8	1,501	1.03	0.58
	4	0.300	200.00	25.00	0.0500	1.0000	1	63.8	30,159	21.19	11.96
	5	0.240	200.00	0.00	0.0010	1.0000	2	0.0	2	0.00	0.00
	6	0.240	200.00	12.00	0.0500	1.0000	2	100.8	12,535	9.16	5.00
	7	0.240	200.00	15.00	0.0500	1.0000	2	119.0	15,924	11.63	6.58
Σ								5,229.7	112,393	82.03	40.88

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	45.00	45.00	100.00	6.700	0.004
		8. Large gullies, diversions, and low flowing streams	6.67	60.00	900.00	7.740	0.032
			0.00	0.00	0.00	0.000	0.000
#1	1	Time of Concentration:					0.036
#1	2	1. Forest with heavy ground litter	25.00	25.00	100.00	1.260	0.022
		8. Large gullies, diversions, and low flowing streams	4.21	80.00	1,900.05	6.150	0.085
#1	2	Time of Concentration:					0.107

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10

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	3	1. Forest with heavy ground litter	20.00	20.00	100.00	1.130	0.024
		8. Large gullies, diversions, and low flowing streams	5.71	160.00	2,800.04	7.170	0.108
#1	3	Time of Concentration:					
#1	4	3. Short grass pasture	10.00	10.00	100.00	2.520	0.011
		8. Large gullies, diversions, and low flowing streams	17.14	60.00	350.00	12.420	0.007
#1	4	Time of Concentration:					
#1	6	5. Nearly bare and untilled, and alluvial valley fans	15.00	30.00	199.99	3.870	0.014
		8. Large gullies, diversions, and low flowing streams	1.43	20.00	1,400.07	3.580	0.108
#1	6	Time of Concentration:					
#1	7	5. Nearly bare and untilled, and alluvial valley fans	15.00	30.00	199.99	3.870	0.014
			1.79	25.00	1,400.01	0.000	0.000
#1	7	Time of Concentration:					
							0.014

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.31	60.00	2,600.10	4.550	0.158
#1	1	Muskingum K:					
#1	2	8. Large gullies, diversions, and low flowing streams	4.40	55.00	1,250.00	6.290	0.055
#1	2	Muskingum K:					
#1	3	8. Large gullies, diversions, and low flowing streams	3.93	55.00	1,400.02	5.940	0.065
#1	3	Muskingum K:					
#1	4	8. Large gullies, diversions, and low flowing streams	6.39	115.00	1,800.02	7.580	0.065
#1	4	Muskingum K:					
#1	6	8. Large gullies, diversions, and low flowing streams	2.00	30.00	1,500.00	4.240	0.098
#1	6	Muskingum K:					
							0.098

Black Warrior Minerals, Inc.
Seaboard Mine
P-3937 R-5
Basin 021 Re-evaluation
Hydrology & Sedimentology
25 Yr. - 6 Hr. Event

BLACK WARRIOR MINERALS, INC.

SEABOARD MINE

P-3937 Revision R-5

BASIN 021 Re-evaluation

5.1 INCHES, 25 YEAR - 6 HOUR, NRCS 6 HOUR

LGS

PERC Engineering Co., Inc.
P.O. Box 1712
Jasper, Alabama 35502

Phone: 205-295-3127
Email: lstephens@percengineering.com

General Information***Storm Information:***

Storm Type:	Rainfall Event
-------------	----------------

Accumulated Time (hrs)	Accumulated Depth (in)
0.00	0.0000
0.50	0.1790
1.00	0.4080
1.50	0.6890
2.00	1.1730
2.50	3.0600
3.00	3.5700
3.50	3.9780
4.00	4.2590
4.50	4.5140
5.00	4.7180
5.50	4.9220
6.00	5.1000

Peak 30-minute Intensity: 3.774 in/hr

Particle Size Distribution:

Size (mm)	TOPSOIL	SPOIL
3.0000	100.000%	100.000%
2.0000	90.000%	95.000%
1.0000	82.000%	85.000%
0.5000	73.000%	70.000%
0.3000	68.000%	50.000%
0.2000	63.000%	45.000%
0.1000	38.000%	20.000%
0.0500	20.000%	15.000%
0.0300	16.000%	13.000%
0.0200	14.000%	12.000%
0.0100	11.500%	7.500%
0.0050	10.000%	5.000%
0.0030	9.500%	4.000%

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3

Size (mm)	TOPSOIL	SPOIL
0.0010	8.500%	3.500%

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Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Pond	#1	=>	End	0.000	0.000	BASIN 021

#1
Pond

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)	
#1	In Out	265.590	265.590	450.02 273.90	47.26 43.54	6,668.6 395.8	211,693 12,385	154.51 0.11	71.96 0.06

Particle Size Distribution(s) at Each Structure***Structure #1:***

Size (mm)	In	Out
3.0000	100.000%	100.000%
2.0000	95.041%	100.000%
1.0000	85.106%	100.000%
0.5000	70.208%	100.000%
0.3000	50.441%	100.000%
0.2000	45.430%	100.000%
0.1000	20.375%	100.000%
0.0500	15.125%	100.000%
0.0300	13.084%	100.000%
0.0200	12.063%	100.000%
0.0100	7.590%	100.000%
0.0050	5.103%	85.981%
0.0030	4.110%	69.250%
0.0010	3.600%	60.652%

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Structure Detail:

Structure #1 (Pond)

BASIN 021

Pond Inputs:

Initial Pool Elev:	342.25 ft
Initial Pool:	4.12 ac-ft
*Sediment Storage:	11.10 ac-ft
Dead Space:	20.00 %

**Sediment capacity was entered by user*

Emergency Spillway

Spillway Elev	Crest Length (ft)	Left Sideslope	Right Sideslope	Bottom Width (ft)
344.75	12.00	2.00:1	2.00:1	10.00

Fixed Siphon

Crest Elev	Inlet Elev	Outlet Elev	Diameter (in)	Length (ft)	Manning's n
344.25	342.25	340.00	3.00	100.00	0.0140

Pond Results:

Peak Elevation:	348.23 ft
H'graph Detention Time:	1.23 hrs
Pond Model:	CSTRS
Dewater Time:	9.16 days
Trap Efficiency:	94.06 %

Dewatering time is calculated from peak stage to lowest spillway

Elevation-Capacity-Discharge Table

Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
339.73	1.538	0.000	0.000	Top of Sed. Storage
340.00	1.553	0.411	0.000	
340.50	1.594	1.198	0.000	
341.00	1.635	2.005	0.000	
341.50	1.677	2.833	0.000	
342.00	1.720	3.683	0.000	

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Elevation	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	Dewater Time (hrs)
342.25	1.744	4.116	0.000	
342.50	1.769	4.555	0.219	24.31*
343.00	1.818	5.451	0.242	44.87*
343.50	1.868	6.373	0.263	42.33*
344.00	1.918	7.319	0.284	40.39*
344.25	1.940	7.801	0.293	19.90* Spillway #2
344.50	1.963	8.289	0.303	19.51*
344.75	1.986	8.783	0.312	19.45 Spillway #1
345.00	2.009	9.282	5.198	3.50
345.50	2.055	10.298	14.970	1.30
346.00	2.101	11.337	39.684	0.55
346.50	2.166	12.403	74.992	0.65
347.00	2.231	13.502	119.604	1.80
347.50	2.298	14.634	174.153	0.65
348.00	2.365	15.800	238.944	0.40
348.23	2.398	16.356	273.905	0.15 Peak Stage
348.50	2.435	17.000	314.326	
349.00	2.506	18.235	400.666	
349.50	2.558	19.501	498.335	
350.00	2.610	20.793	607.703	

*Designates time(s) to dewater have been extrapolated beyond the 50 hour hydrograph limit.

Detailed Discharge Table

Elevation (ft)	Emergency Spillway (cfs)	Fixed Siphon (cfs)	Combined Total Discharge (cfs)
339.73	0.000	0.000	0.000
340.00	0.000	0.000	0.000
340.50	0.000	0.000	0.000
341.00	0.000	0.000	0.000
341.50	0.000	0.000	0.000
342.00	0.000	0.000	0.000
342.25	0.000	0.000	0.000
342.50	0.000	0.219*	0.219
343.00	0.000	0.242*	0.242
343.50	0.000	0.263*	0.263
344.00	0.000	0.284*	0.284
344.25	0.000	0.293	0.293
344.50	0.000	0.303	0.303

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Elevation (ft)	Emergency Spillway (cfs)	Fixed Siphon (cfs)	Combined Total Discharge (cfs)
344.75	0.000	0.312	0.312
345.00	4.877	0.321	5.198
345.50	14.631	0.338	14.970
346.00	39.329	0.355	39.684
346.50	74.621	0.371	74.992
347.00	119.218	0.386	119.604
347.50	173.752	0.401	174.153
348.00	238.528	0.416	238.944
348.50	313.896	0.430	314.326
349.00	400.222	0.444	400.666
349.50	497.877	0.458	498.335
350.00	607.233	0.471	607.703

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	28.000	0.036	0.158	0.364	81.000	F	81.54	7.136
	2	26.720	0.107	0.055	0.394	68.000	M	51.96	4.316
	3	129.250	0.132	0.065	0.389	70.000	M	174.48	18.475
	4	8.100	0.018	0.065	0.408	80.000	M	23.01	2.001
	5	2.000	0.000	0.000	0.000	100.000	F	7.61	0.847
	6	37.720	0.122	0.098	0.357	74.000	M	90.42	7.638
	7	33.800	0.014	0.000	0.000	74.000	M	81.02	6.844
Σ		265.590						450.02	47.257

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.240	200.00	35.00	0.9000	0.9000	2	6,170.2	726,427	530.68	360.64
	2	0.240	200.00	20.00	0.0500	1.0000	2	122.9	34,501	25.20	15.16
	3	0.300	200.00	15.00	0.0030	1.0000	1	32.5	2,058	1.39	0.87
	4	0.300	200.00	25.00	0.0500	1.0000	1	81.2	48,252	33.91	20.67
	5	0.240	200.00	0.00	0.0010	1.0000	2	0.0	3	0.00	0.00
	6	0.240	200.00	12.00	0.0500	1.0000	2	122.5	20,232	14.78	8.57
	7	0.240	200.00	15.00	0.0500	1.0000	2	144.7	25,622	18.72	11.27
Σ								6,668.6	211,693	154.51	71.96

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	45.00	45.00	100.00	6.700	0.004
		8. Large gullies, diversions, and low flowing streams	6.67	60.00	900.00	7.740	0.032
			0.00	0.00	0.00	0.000	0.000
#1	1	Time of Concentration:					0.036
#1	2	1. Forest with heavy ground litter	25.00	25.00	100.00	1.260	0.022
		8. Large gullies, diversions, and low flowing streams	4.21	80.00	1,900.05	6.150	0.085
#1	2	Time of Concentration:					0.107

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11

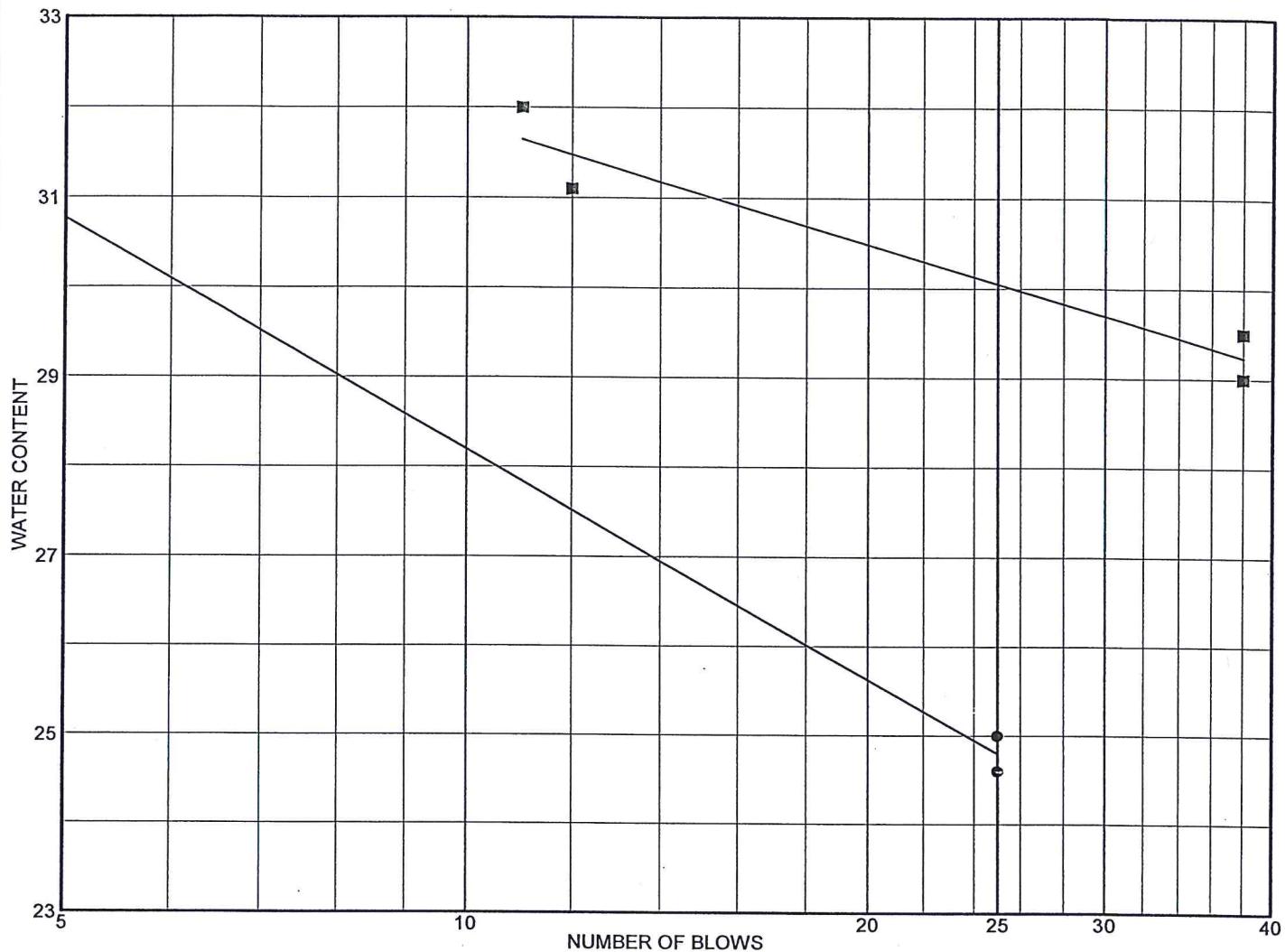
Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	3	1. Forest with heavy ground litter	20.00	20.00	100.00	1.130	0.024
		8. Large gullies, diversions, and low flowing streams	5.71	160.00	2,800.04	7.170	0.108
#1	3	Time of Concentration:					
#1	4	3. Short grass pasture	10.00	10.00	100.00	2.520	0.011
		8. Large gullies, diversions, and low flowing streams	17.14	60.00	350.00	12.420	0.007
#1	4	Time of Concentration:					
#1	6	5. Nearly bare and untilled, and alluvial valley fans	15.00	30.00	199.99	3.870	0.014
		8. Large gullies, diversions, and low flowing streams	1.43	20.00	1,400.07	3.580	0.108
#1	6	Time of Concentration:					
#1	7	5. Nearly bare and untilled, and alluvial valley fans	15.00	30.00	199.99	3.870	0.014
			1.79	25.00	1,400.01	0.000	0.000
#1	7	Time of Concentration:					
							0.014

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	2.31	60.00	2,600.10	4.550	0.158
#1	1	Muskingum K:					
#1	2	8. Large gullies, diversions, and low flowing streams	4.40	55.00	1,250.00	6.290	0.055
#1	2	Muskingum K:					
#1	3	8. Large gullies, diversions, and low flowing streams	3.93	55.00	1,400.02	5.940	0.065
#1	3	Muskingum K:					
#1	4	8. Large gullies, diversions, and low flowing streams	6.39	115.00	1,800.02	7.580	0.065
#1	4	Muskingum K:					
#1	6	8. Large gullies, diversions, and low flowing streams	2.00	30.00	1,500.00	4.240	0.098
#1	6	Muskingum K:					
							0.098

**Black Warrior Minerals, Inc.
Seaboard Mine
P-3937 R-5
Soil Classification**

LIQUID AND PLASTIC LIMITS TEST REPORT



MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
● Silty, clayey sand	25	20	5	90.72	28.6	SC-SM
■ Silty sand	30	24	6	84.08	21.3	SM

Project No. Client: Black Warrior Minerals Inc.

Project: Basin 021

Basin 021

● Location: Seaboard Mine

■ Location: Seaboard Mine

Remarks:

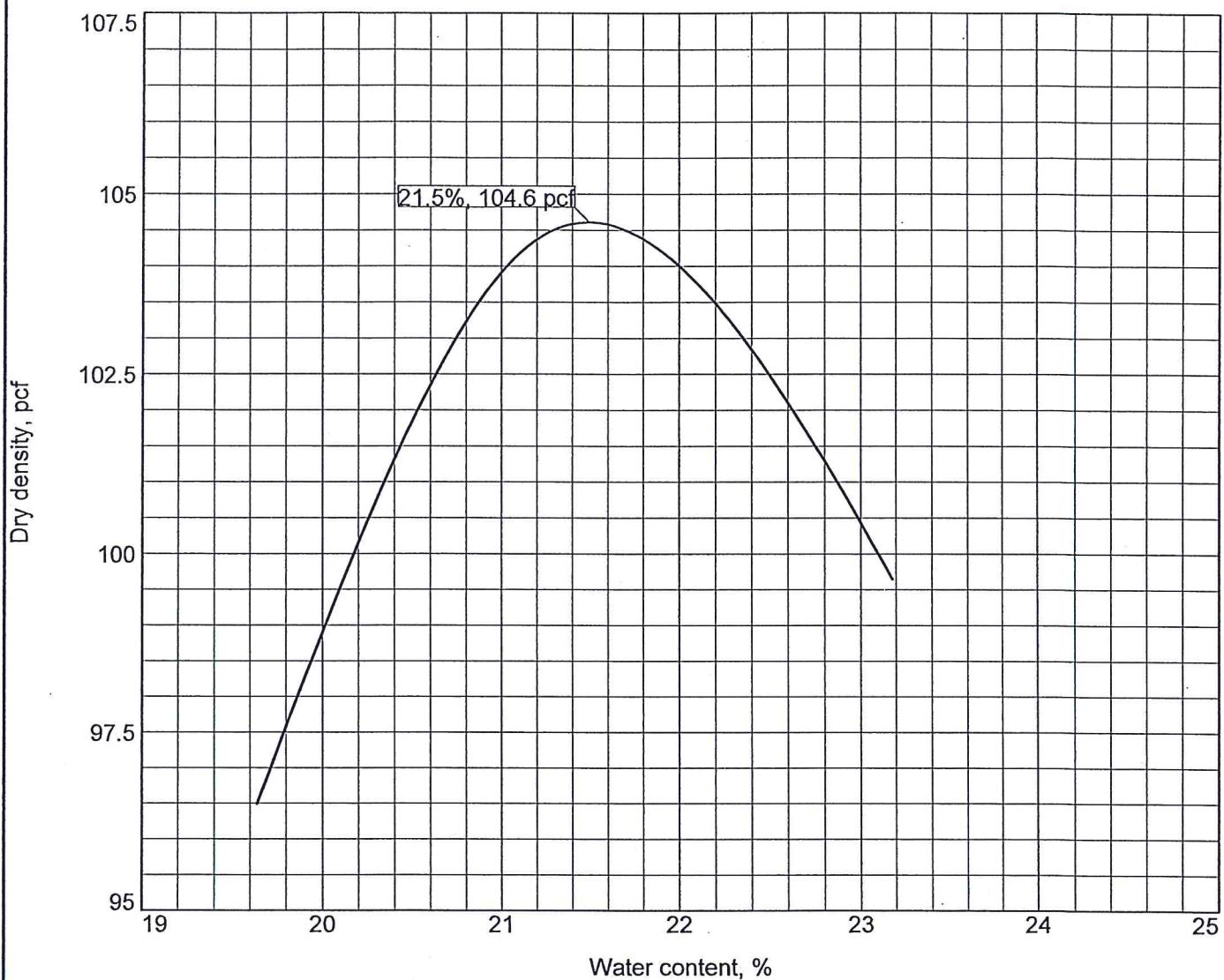
- Dam Material
- Foundation Material

PERC ENGINEERING CO., INC.

Jasper, Alabama

Date 9-23-14

COMPACTION TEST REPORT



Test specification: ASTM D 698-91 Procedure B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
	SC-SM				25	5		28.6

TEST RESULTS				MATERIAL DESCRIPTION			
Maximum dry density = 104.6 pcf				Silty, clayey sand			
Optimum moisture = 21.5 %							
Project No.	Client: Black Warrior Minerals Inc.			Remarks:			
Project: Basin 021	Date:						
○ Location: Seaboard Mine							
PERC ENGINEERING CO., INC.							
Jasper, Alabama				Date 9-23-14			

**Black Warrior Minerals, Inc.
Seaboard Mine
P-3937 R-5
Basin 021 Re-evaluation
Stability Analysis**

Black Warrior Minerals, Inc.
Seaboard Mine P-3937 R-5

STABILITY ANALYSIS DATA

METHODOLOGY

The static loading stability analyses were performed using the Simplified Bishop Method. The computer program used was the REAME Slope Stability Program as developed by Dr. Yang H. Huang, P.E. of the University of Kentucky.

SOIL CLASSIFICATION UNITS

The soil type (soil classification) to be used in the construction of the embankment structure of Basin 021 Re-evaluation(SC-SM and the soil type (soil classification) of the material between the proposed embankment and stiff base of Basin 021 Re-evaluation(SM) were sampled and analyzed by PERC Engineering Co., Inc. The soil properties used in the stability analysis (SC-SM), and (SM) type soils, were taken from the U.S. Department of the Interior Bureau of Reclamation Design of Small Dams.*

SOIL PROPERTIES

	UNIFIED CLASS	COHESION (PSF)	ANGLE OF INT. FRICTION	DESIGN DENSITY (PCF)
Dam Material Basin 021 Re-evaluation	SC-SM	187.2	30.5	136.0
Foundation Basin 021 Re-evaluation	SM	273.6	33.0	132.1

*United States Department of Interior Bureau of Reclamation Design of Small Dams page 137.

Black Warrior Minerals, Inc.
Seaboard Mine P-3937 R-5

STABILITY ANALYSIS DATA

(Continued)

DESIGN DATA

- 1) Design Density = 95% of the standard proctor maximum density.
- 2) Embankment top width: 12.0'.
- 3) Freeboard minimum = 10% of structure (from top of embankment to normal pool level).
- 4) Safety factors for embankments with 2.5H:1V slopes, front and back.
- 5) Basin 021 design height = *19.6 ft.
- 6) DMIN = 0.00
- 7) All design heights are measured from the top of the embankment to the toe of the upstream slope.
- 8) * Indicates Basin 021 Re-evaluation incised 9.0 ft.

SAFETY FACTORS

BASIN NUMBER	STATIC SAFETY FACTOR
Basin 021 Re-evaluation	2.65

FOUNDATIONS AND ABUTMENTS

The foundation and abutments area will be inspected for visible structural deficiencies after clearing and grubbing, and if found they will be treated using sound engineering practices.

BWMSB021
REAME (Rotational Equilibrium Analysis of Multilayered Embankments)
Implemented on the 16-bit Microcomputers C. F. Hains, Jr. and D. M. Hains
2301 22nd Ave.
Northport, AL 35476
(205)-339-6536

Black Warrior Minerals P-3937 Basin 021

Number of cases to be analyzed 1

Case Number 1

Number of boundary lines= 4
Number of points on boundary lines are: 2 2 3

7

On boundary line no. 1 Point no. and coordinates are:
1 56.250 17.750 2 500.000 .000

On boundary line no. 2 Point no. and coordinates are:
1 200.000 14.000 2 272.222 11.111

On boundary line no. 3 Point no. and coordinates are:
1 56.250 19.750 2 200.000 14.000 3 214.375 19.750

On boundary line no. 4 Point no. and coordinates are:
1 56.250 19.750 2 214.375 19.750 3 226.500 24.600 4
238.500 24.600 5 268.335 12.666
6 272.222 11.111 7 500.000 2.000

Line no. and slope of each segment are:

1	-.040					
2	-.040					
3	-.040	.400				
4	.000	.400	.000	-.400	-.400	-.040

No. of radius control zones= 1 Plot or no plot= 1 No. of seepage cases= 1

Total no. of lines at bottom of radius control zones is: 1

For rad. cont. zone no. 1 Radius decrement= .000 No. of Circles=
5 Id no. for first circle=, 1
Line no.= 1 Begin pt. no.= 1 End pt. no.= 2

Soil no.	Cohesion	F. angle	Unit wt.
1	273.600	33.000	132.100
2	187.200	30.500	136.000
3	.000	.000	62.400

Seismic coefficient=.000 Min. depth of tallest slice=.000
Unit weight of water= 62.400

The factors of safety are determined by the SIMPLIFIED BISHOP method

NSPG= 1 NSRCH= 0 No. of slices= 10 No. of add. radii= 2

BWMSB021

No. of points on water table for each case= 6

Under seepage condition 1 point no. and coordinates of water table
are:

1	56.250	19.750	2	214.375	19.750	3	239.199	17.590	4
268.335	12.666	5	272.222	11.111					
6	500.000		2.000						

point1=(240.000, 46.000) point2=(240.000, 26.000) point3=(273.000, 26.000) NJ= 2 NI= 2
Automatic search will follow after grid with XINC= 10.000 and YINC= 10.000

At point (240.000, 46.000) under seepage 1, the radius and the corresponding factor of safety are:

35.572	7.743	32.748	7.010	29.924	7.263
27.100	7.655	24.276	10.779		
30.865	34.630	7.566	33.689	7.209	31.806
	7.150				7.059

Lowest factor of safety= 7.010 and occurs at radius = 32.748

At point (240.000, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

25.580	6.994	22.763	6.298	19.947	6.450
17.131	6.994	14.315	9.316		
20.886	24.641	6.811	23.702	6.485	21.825
	6.345				6.319

Lowest factor of safety= 6.298 and occurs at radius = 22.763

At point (240.000, 26.000) under seepage 1, the radius and the corresponding factor of safety are:

15.588	7.332	12.841	6.890	10.095	7.435
7.349	7.796	4.603	8.384		
11.011	14.672	7.295	13.757	7.019	11.926
	7.251				7.071

Lowest factor of safety= 6.890 and occurs at radius = 12.841

At point (256.500, 46.000) under seepage 1, the radius and the corresponding factor of safety are:

36.231	2.894	34.296	2.807	32.360	2.996
30.425	3.386	28.490	4.539		
33.005	35.586	2.904	34.941	2.892	33.651
	2.901				2.814

Lowest factor of safety= 2.807 and occurs at radius = 34.296

At point (256.500, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

26.239	2.841	24.445	2.798	22.651	2.956
20.857	3.503	19.064	4.934		
23.249	25.641	2.847	25.043	2.845	23.847
	2.845				2.747

Lowest factor of safety= 2.747 and occurs at radius = 23.847

At point (256.500, 26.000) under seepage 1, the radius and the corresponding factor of safety are:

16.247	3.248	14.595	3.299	12.942	3.447
11.290	4.075	9.637	5.583		

Lowest factor of safety= 3.248 and occurs at radius = 16.247

At point (273.000, 46.000) under seepage 1, the radius and the

BWMSB021

corresponding factor of safety are:

36.890	3.729	36.049	4.013	35.207	4.317
34.366	4.793	33.524	8.214		
Lowest factor of safety=			3.729 and occurs at radius =	36.890	

At point (273.000, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

26.898	4.400	26.198	4.793	25.498	5.373
24.798	5.373	24.098	9.484		
24.331	25.265	5.592	25.031	5.675	24.565
Lowest factor of safety=			4.400 and occurs at radius =	26.898	

At point (273.000, 26.000) under seepage 1, the radius and the corresponding factor of safety are:

16.906	5.673	16.348	6.264	15.789	7.236
15.230	8.891	14.672	11.264		
Lowest factor of safety=			5.673 and occurs at radius =	16.906	

For piezometric line No. 1

At point (256.500, 36.000), RADIUS 23.847
the minimum factor of safety is 2.747

At point (256.500, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

26.239	2.841	24.445	2.798	22.651	2.956
20.857	3.503	19.064	4.934		
23.249	25.641	2.847	25.043	2.845	23.847
Lowest factor of safety=			2.747 and occurs at radius =	23.847	

At point (266.500, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

26.639	2.979	25.508	3.096	24.377	3.211
23.246	4.161	22.115	6.640		
Lowest factor of safety=			2.979 and occurs at radius =	26.639	

At point (246.500, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

25.839	4.039	23.383	3.744	20.926	3.945
18.469	4.152	16.012	4.836		
21.745	25.020	3.993	24.202	3.891	22.564
Lowest factor of safety=			3.744 and occurs at radius =	23.383	

At point (256.500, 46.000) under seepage 1, the radius and the corresponding factor of safety are:

36.231	2.894	34.296	2.807	32.360	2.996
30.425	3.386	28.490	4.539		
33.005	35.586	2.904	34.941	2.892	33.651
Lowest factor of safety=			2.807 and occurs at radius =	34.296	

At point (256.500, 26.000) under seepage 1, the radius and the corresponding factor of safety are:

BWMSB021

11.290	16.247	3.248	14.595	3.299	12.942	3.447
	4.075	9.637	5.583			
Lowest factor of safety=			3.248 and occurs at radius =		16.247	

At point (259.000, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

21.454	26.339	2.740	24.711	2.788	23.083	2.969
	3.618	19.826	5.219			
Lowest factor of safety=			2.740 and occurs at radius =		26.339	

At point (261.500, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

22.052	26.439	2.727	24.976	2.837	23.514	3.017
	3.758	20.589	5.578			
Lowest factor of safety=			2.727 and occurs at radius =		26.439	

At point (264.000, 36.000) under seepage 1, the radius and the corresponding factor of safety are:

22.649	26.539	2.788	25.242	2.942	23.945	3.090
	3.932	21.352	6.037			
Lowest factor of safety=			2.788 and occurs at radius =		26.539	

At point (261.500, 38.500) under seepage 1, the radius and the corresponding factor of safety are:

24.443	28.937	2.678	27.439	2.772	25.941	2.960
	3.683	22.946	5.456			
Lowest factor of safety=			2.678 and occurs at radius =		28.937	

At point (261.500, 41.000) under seepage 1, the radius and the corresponding factor of safety are:

26.835	31.435	2.650	29.902	2.725	28.369	2.910
	3.614	25.302	5.345			
Lowest factor of safety=			2.650 and occurs at radius =		31.435	

At point (261.500, 43.500) under seepage 1, the radius and the corresponding factor of safety are:

29.227	33.933	2.650	32.364	2.698	30.796	2.869
	3.549	27.659	5.243			
Lowest factor of safety=			2.650 and occurs at radius =		33.933	

At point (264.000, 41.000) under seepage 1, the radius and the corresponding factor of safety are:

27.432	31.535	2.686	30.167	2.813	28.800	2.987
	3.789	26.065	5.765			
Lowest factor of safety=			2.686 and occurs at radius =		31.535	

At point (259.000, 41.000) under seepage 1, the radius and the corresponding factor of safety are:

26.238	31.335	2.717	29.636	2.724	27.937	2.878
	3.468	24.539	5.012			
Lowest factor of safety=			2.717 and occurs at radius =		31.335	

For piezometric line No. 1

At point (261.500, 41.000), RADIUS 31.435
the minimum factor of safety is 2.650

